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ABSTRACT

This paper focuses on whether the Response to Educational Needs Project (RENP) has been demonstrated to be a cost effective way of increasing the reading and mathematical achievement scores of students in the fourth, fifth, and eighth grades of the District of Columbia Public Schools. The first section describes the RENP program and its history. The second sketches some of the important considerations relevant to properly understanding cost effectiveness analysis and the cost and effectiveness data on which the analysis is based. The third presents the data, analyzing fall to fall comparisons for reading and mathematics scores, fall to spring comparisons for reading and mathematics, and fall to spring comparisons using adjusted gain scores. (Author/MC)

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RMC Report UR-330

IS RENC A COST-EFFECTIVE SUPPLEMENT TO
TO THE REGULAR DCPS PROGRAM?

Michael T. Ertecart

February 1978

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INTRODUCTION

This paper is one of a series of papers addressing policy issues relevant to the Response to Educational Needs Project (RENP). The focus of this paper is on whether RENP has been demonstrated to be a cost-effective way of increasing the reading and mathematical achievement scores of students in the fourth, fifth, sixth, and eighth grades of the District of Columbia Public Schools (DCPS).

PURPOSE

The purpose of a cost-effectiveness analysis is to provide a systematic way for policy makers to choose among programs competing for limited resources. Unfortunately, it is not possible to say exactly what a cost-effectiveness analysis is, as it varies from application to application depending upon the data available and the objectives of the policy-makers. As Dr. Levin¹ says:

"...there is no standard set of applied rules that can be mastered to carry out cost-effectiveness comparisons. Rather, there is a set of principles and considerations that must be combined with sensitivity, ingenuity, and intuition on the part of the analyst."

In this instance, our focus is on analyzing the available data to determine whether (1) RENP has been shown to produce increases in student achievement; and (2) if so, whether these increases justify the additional costs of RENP.

This paper is organized into three principal sections. The first section describes in a general way the RENP program and its history. The second sketches some of the important considerations relevant to properly understanding cost effectiveness analysis and the cost and effectiveness data on which the analysis is based. The third presents our data and conclusions. A separate volume of appendices contains background material on details concerning the derivation of the cost data as well as the basic

1. Levin, H.M., "Cost Effectiveness in Educational Research," in Guttentag and Strueing (eds.), Handbook of Evaluation Research (Beverly Hills, California: SAGE Publications, 1975), p. 91.

effectiveness data provided to the author by Richard A. Gibboney Associates, Inc.

THE RESPONSE TO EDUCATIONAL NEEDS PROJECT (RENP)

RENP is a compensatory education project whose primary objective is to increase the reading and mathematical abilities of children. RENP uses a three-pronged approach to achieve this end:

- (1) A major part of RENP resources are focused upon enhancing the skills of teachers. It is thought that increasing teachers' abilities will result in enhanced student progress. Further, this strategy should prove cost-effective in that a teacher, once trained, can be expected to benefit students over his entire teaching career.
- (2) RENP also provides direct instruction of students in mathematics and reading and strives to create individualized programs.
- (3) RENP from its inception has emphasized the involvement of the community in the schools and has sought to actively involve parents and communities in policy and decision processes.

RENP has been operating for approximately ten years in the Anacostia section of Washington, D.C., and has received Federal funding of approximately \$7 million during that time. While many of the ideas described above have always been a part of the RENP concept, only comparatively recently (1975-1976 school year), has the structure been formalized. RENP, by 1977, had structured its program into three components: reading, mathematics, and parent/community involvement. For each school involved in reading, RENP provided a laboratory in the school staffed by a program facilitator who trained teachers, and aides who instructed students. A similar organizational format was followed by the mathematics labs. The reading and mathematics labs operated independently of one another, even when they were located in the same school. The parent/community involvement component employed one community organizer per two labs. This person served as a liaison between the parents and community, RENP, DCPS, and the local school. RENP was operating ten reading labs and ten mathematics labs in one high school, one junior high school, and several elementary schools. At the end of the 1977 school year, the formal RENP program ended, however, funding to disseminate RENP concepts and technique has been continued by the National Institute of Education.

METHODOLOGICAL CONSIDERATIONS

Cost Effectiveness Analysis Criteria

The objective of a cost-effectiveness analysis is to enable a policy-maker faced with competing alternatives to allocate his or her funds most effectively. There are several necessary conditions for this analytical technique to be employed:

- (1) The costs measured must have produced the effects observed.

Although this would seem to be a simple requirement, in any practical situation it can only be imperfectly realized. For example, suppose we have determined that a tape recorder is available to a single classroom along with a library of tapes designed to improve reading skills. If the teacher chooses not to use this tape recorder, then the cost of the recorder should not be considered one of the costs of producing gains in reading. The situation described is an instance of discriminating between the availability of resources and the utilization of the resources. Another example of this problem lies in the fact that the tape recorder, even if used, will probably not be used equally by all students in the classroom. Thus, the exact package of resources provided to each student varies from student to student.

The work "produced" can legitimately be used in a very loose sense. For example, a regular hot lunch can well produce reading gains by making the student healthier and better able to concentrate in the classroom. As a second example, the cost of the school principal is properly included as the proper performance of that job ensures that necessary instructional resources will be available and that the school environment will be conducive to learning.

- (2) The measures of effectiveness must be carefully chosen. An innovative educational program such as RENP produces many different kinds of effects. For example, RENP produces effects in student achievement in reading and mathematics; in teacher skills; in school-community relations; in training community people to function as teacher's aides; and in many

other dimensions.

It is quite likely that the results of a cost-effectiveness analysis will depend on the measures chosen. For example, if a program administrator were choosing between the RENT reading program and the regular DCPS program, he might choose RENT if he used reading comprehension as the measure of effectiveness, but the DCPS program if he used reading vocabulary as the measure of effectiveness. If the policymaker attempts to use two or more measures of effectiveness then he must be prepared to subjectively (or objectively) weight the various measures. Such a weighting cannot be prescribed analytically--it is essentially a quantification of social and philosophical values and objectives.

(3) The programs compared must be alternatives. For example, one cannot compare a compensatory mathematics program to a compensatory reading program, as they are not designed to achieve the same objective. In the case of RENT it is accurate to say that both RENT and the DCPS program have as objectives the enhancement of student skills in reading and mathematics. Reading and mathematics do not constitute the entire goal-set of either alternative, however. DCPS, for example, provides physical education while RENT does not. RENT, on the other hand, provides community organizers to improve school-community relations, while DCPS does not. Thus, RENT is not actually an alternative to the regular DCPS program. The actual alternatives compared in this analysis are: (1) the DCPS program; and (2) the DCPS program when supplemented by RENT.

Although the above considerations are by no means a definitive list of the criteria for performing cost-effectiveness analysis, they do illustrate some of the relevant considerations and difficulties in doing such analyses. We now turn to the measures employed in this analysis.

The Measures of Effectiveness

In this paper we will focus solely on the changes in student performance on the Comprehensive Test of Basic Skills (CTBS). Three administrations of this test were made: Fall, 1976; Spring, 1977; and Fall, 1977. We will measure the changes in student performance in three ways:

(1) The first measure employed will be the adjusted gain score. This score is calculated as follows: (a) Convert the Fall, 1976 CTBS

score in the dimension under consideration into a percentile rank; (b) using the Spring, 1977 norms convert the Fall, 1976 percentile rank into the score which would produce that rank in Spring, 1977; (c) calculate the difference between the students actual score in Spring, 1977, and the score calculated in (b). This is the adjusted gain score (AGS). We will use the classroom/level as the unit of analysis for the AGS. Specifically, each classroom will provide three observations: (1) the average AGS for students classified as "low" on the CTBS pretest; (2) the average AGS for students classified as "middle" on the CTBS pretest; and (3) the average AGS for students classified as "high" on the CTBS pretest.

The AGS has the theoretical advantage that it is positive only if the student gained in percentile ranks between the test administrations. (The raw score difference could be positive when the student actually lost in terms of percentiles.) It has the disadvantage that the actual units are not meaningful. For example, a student initially at the fifth percentile who scored five points above the fifth percentile-equivalent point score in the Spring might have shot up 15 or more percentile points, whereas a student initially at the 50th percentile who registered a five point raw score gain above the Spring 50th percentile might have only gone up four or five percentile points.

The AGS is theoretically the soundest measure used in this analysis. Unfortunately, it was not calculated for total reading and total math scores and it was not calculated between Fall, 1976 and Fall, 1977 test administrations. Therefore, we have had to rely on other measures.

(2) The second measure employed will be the raw gain score (RGS). The raw gain score (RGS) is simply the difference in test scores between any two test administrations. Although it is not a particularly sound measure, it will be used since better measures are unavailable. Estimates of dispersion were available for this statistic so that hypothesis tests could be performed using this measure. This measure was available for the total scores in reading and mathematics and could be used to measure Fall-Spring and Fall-Fall changes. When using the RGS, the student will be the unit of analysis.

(3) The third measure employed will be the large-city schools percentile change (PC). This measure is possibly the best of the measures used

here, as the interpretation of the PC is independent of the student's pretest level, although there are ceiling effects. Unfortunately, no measures of dispersion for these statistics are available. That means that we are unable to attach any statistical significance to changes in percentile ranks. We will not be able to determine whether the observed differences arose by chance or not. Rather, the data must be used in an intuitive fashion along with the other measures of achievement gain. Percentile analysis will be done using the student as the unit of analysis.

There is no special reason for using the classroom-level as the unit of analysis for the AGS and the student as the unit of analysis for the RGS and percentile changes. The raw data was provided to the author in this format.

In summary, the three types of outcome measures outlined above will be used in this analysis. The measures all suffer from theoretical and practical limitations and consequently the analyses to follow must be viewed as tentative interpretations of the data.

Statistical Significance Testing

Results will be called "significant" if their associated statistics exceed the .10 significance.

THE EFFECTIVENESS DATA

Fall-Fall Comparisons

The first analysis of the data will focus on the gains of RENT students between Fall, 1976 and Fall, 1977. For this analysis we will employ only the differences in raw scores and the differences in percentile scores and only consider total reading and mathematics scores.

Table 1 shows the average gain of RENT and non-RENT students in CTBS scores for test administrations in the Fall of 1976 and 1977.

Reading

For reading, no difference was demonstrated in average gains at the sixth grade level. At the fourth, fifth, and eighth grade levels, however, the RENT students produced numerically higher average gains. But, the raw score differences between RENT and non-RENT were not statistically significant, except at the eighth grade.

Gains in percentile ranks are more important than gains in raw test scores because percentile gains are relative to a national reference group. RENP students made numerically larger gains in reading percentile rankings than did the non-RENP students--at all grade levels.

Mathematics

For mathematics, RENP students were slightly ahead of the non-RENP students at the fourth grade level. At the fifth, sixth, and eighth grade levels the non-RENP students achieved larger gains between the two rounds of testing. Differences between RENP and non-RENP raw scores were found not to be statistically significant at the fourth, sixth, and eighth grade levels; the non-RENP score gains were significantly higher at the fifth grade level.

The percentile gains for mathematics confirmed the direction of the differences observed using raw gains. Non-RENP students made larger percentile gains at the fifth, sixth, and eighth grade levels, but RENP students did better at the fourth grade level. Again, this information must be used cautiously as no statistical judgments can be made concerning the significance of the observed differences.

Table 1
GAINS BETWEEN FALL, 1976 AND FALL, 1977

	READING-TOTAL SCORE						MATHEMATICS-TOTAL SCORE					
	N ¹	Points ²	S.E. ³	\$/Pts ⁴	Peren- ⁵ tiles	\$/PC	N	Points	S.E.	\$/Pts	Peren- tiles	\$/PC
4th												
REXP	70	14	2.8	112	+ 3	522	63	18	3.1	85	+ 1	\$1,580
NON-REXP	75	11	3.3	108	- 3	-	62	16	3.5	75	- 3	-
5th												
REXP	78	12	2.3	130	+10	156	63	9	2.7	171	0	-
NON-REXP	30	7	3.9	169	+ 1	1,187	28	17*	3.6	69	+13	91
6th												
REXP	46	10	3.2	156	+ 9	177	37	10	3.6	154	+ 3	513
NON-REXP	18	10	6.2	119	+ 4	297	10	14	6.7	85	+ 5	238
8th												
REXP	137	10*	1.8	156	+ 7	223	115	+10	2.1	154	+ 8	192
NON-REXP	80	+ 6	2.4	198	+ 0	-	63	+12	2.6	99	+10	110

1. Number of students
 2. Difference in average raw test scores between the two administrations, using the student as the unit of analysis
 3. Standard error of average difference
 4. Average cost per student : average gain
 5. Average change in percentile
 6. Average cost per student : average percentile gain if latter quantity is positive
- * Significant at the .10 level

Summary of Fall-Fall Comparisons

In summary, the average gain recorded by RENP students in reading was as good or better than that recorded by non-RENP students at all grade levels. Except for the eighth grade, there is so much variation in the average scores from classroom to classroom that we cannot discount the possibility that these results arose by chance. The performance of non-RENP students in mathematics was superior to that of RENP students at the fifth, sixth, and eighth grade levels, but slightly inferior at the fourth grade level. The difference at the fifth grade level can be considered statistically significant; all other differences are insignificant.

In the strict sense, the Fall-Fall comparisons are the most proper as a summer component is not an intrinsic part of either RENP or the DCPS program. A case can be made, however, that retention over the summer is an issue outside the scope of the RENP-DCPS comparison and accordingly the proper gain analysis is between Fall, 1976 and Spring, 1977. In any case we will present that analysis.

Fall-Spring Comparison

Table 2 presents the changes in raw gain scores and percentile scores between Fall, 1976 and Spring, 1977. Data on the non-RENP eighth graders is not available for this analysis.

Reading

For reading, at each grade level RENP students made larger gains than did non-RENP students. This was true whether one considered raw score gains or percentile score gains. Only the difference between RENP and non-RENP at the fifth grade level was statistically significant, however.

Mathematics

In mathematics, RENP gains exceeded those of non-RENP at the fifth and sixth grade levels, but the non-RENP students did better at the fourth grade level. This was true whether one considered raw score gains or percentile gains. None of the differences observed were statistically significant.

Table 2
GAINS BETWEEN FALL, 1976 AND SPRING, 1977

	Reading-Total Score						Mathematics-Total Score					
	<u>N</u> ¹	<u>Points</u> ²	<u>S.E.</u> ³	<u>\$/pts</u> ⁴	<u>Peren- tiles</u> ⁵	<u>\$/pc</u> ⁶	<u>N</u>	<u>Points</u>	<u>S.E.</u>	<u>\$/pt</u>	<u>Peren- tiles</u>	<u>\$/pc</u>
4th												
RENP	70	11	2.65	\$143	+ 1	\$1,565	63	9	3.22	\$171	+ 9	\$171
NON-RENP	73	8	3.19	148	- 4	-	62	11	3.42	108	+11	108
5th												
RENP	78	17*	2.32	92	+21	74.5	63	12	2.61	128	+12	128
NON-RENP	50	11	3.64	188	+ 7	224.0	28	11	3.75	108	+11	108
6th												
RENP	46	9	3.13	174	+ 8	196	37	16	3.50	96	+19	81
NON-RENP	18	5	6.35	287	0	-	10	10	6.16	119	+11	108
8th												
RENP	99	4	1.46	392	- 1	-	78	4	2.09	384	+ 5	307
NON-RENP	-	-	-	-	-	-	-	-	-	-	-	-

1. Number of Students
 2. Difference in average raw test scores between the two administrations, using the student as the unit of analysis
 3. Standard error of average difference
 4. Average cost per student : average gain
 5. Average change in percentile
 6. Average cost per student : average percentile gain if latter quantity is positive
- * Significant at the .10 level

Summary of Fall-Spring Comparisons

Thus, the data indicate that the RENP students produced numerically larger gains in both reading and mathematics during the 1976-1977 school year, except for fourth grade mathematics. Unfortunately, there is so much variation in gains between classes, both RENP and non-RENP, that the statistics indicate we cannot be sure that these differences did not arise by chance.

Fall-Spring Comparisons using Adjusted Gain Scores

We have separated these Fall-Spring comparisons from the foregoing because: (1) the analyses were done on reading and mathematics subscales rather than the total score; (2) different analyses were performed; and (3) a different unit of analysis (classroom-level) was used.

Analyses of Variance Methodology

Analyses of variance were run using the adjusted gain score as the dependent variable and crossing treatment (RENP/non-RENP) by grade by level of pretest achievement (low-medium-high) as the main effects and also examining all second-order and third-order interaction terms. Further, the analysis was run on each of the component scales of the reading and math tests, rather than on the total score.

ANOVA Results-Reading

No significant RENP effect was detected in reading vocabulary, but a significant RENP-achievement level interaction was detected. RENP seems to be relatively more effective with students at low pretest achievement levels than with students at higher pretest levels.

A significant main RENP effect was noted in reading comprehension, as well as a significant RENP-grade interaction. RENP did particularly better at the fifth grade level.

ANOVA Results-Mathematics

No significant RENP effects were noted in mathematics applications. And, there were no significant interaction effects involving RENP.

No significant main RENP effect was noted in mathematics computation, but there was evidence of a significant RENP-pretest achievement level-grade level effect, that is, RENP's effectiveness in this dimension was

related both to pretest achievement level and grade level.

A significant main RENP effect was detected in mathematics concepts. Further, a significant RENP-pretest achievement level interaction was detected. As was the case with reading vocabulary, RENP seemed to be relatively more effective with students at low pretest achievement levels.

Adjusted Gain Score Means

As an aid to interpreting the analyses of variance, we have provided Tables 3 and 4 which provide mean adjusted gain scores by grade by RENP/non-RENP by test scale.

In reading vocabulary we see that there appear to be no large RENP/non-RENP differences, except for the fifth grade. Reading comprehension means favor RENP at the fourth and fifth grade levels, but non-RENP at the sixth. The differences in favor of RENP are much larger than the differences favoring non-RENP; this could account for the significant RENP main effect detected in the ANOVA.

Turning to the mathematics scores, we see that there are few strong RENP/non-RENP differences in mathematics applications or computations. In mathematics concepts, RENP scores exceed non-RENP scores at all grade levels; this contributed to the detection of the significant main effect for RENP in the ANOVA.

Table 3
RAW GAIN SCORES-READING

	Vocabulary			Comprehension	
	Cases	M	S.D.	M	S.D.
4th					
REXP	5	1.4	4.5	3.4	5.3
non-REXP	5	1.6	2.3	1.3	5.2
5th					
REXP	6	3.7	4.0	7.1	4.9
non-REXP	3	5.8	2.4	1.4	5.8
6th					
REXP	5	1.5	3.3	3.1	3.1
non-REXP	7	1.6	3.3	3.6	2.1
4th, 5th, 6th					
REXP	16	2.3	3.3	4.7	4.9
non-REXP	15	2.3	3.1	2.4	3.7
8th					
REXP	9	-1.1	3.8	-1.9	4.8
non-REXP	6	-	-	-	-

Table 4
RAW GAIN SCORES-MATHEMATICS

	<u>Computation</u>			<u>Concepts</u>		<u>Applications</u>	
	<u>Cases</u>	<u>M</u>	<u>S.D.</u>	<u>M</u>	<u>S.D.</u>	<u>M</u>	<u>S.D.</u>
4th							
RENT	5	5.7	4.0	2.5	2.0	1.2	3.4
non-RENT	5	7.2	5.5	2.0	1.9	1.1	2.2
5th							
RENT	6	6.0	5.3	2.2	1.9	2.1	2.6
non-RENT	3	4.1	5.1	1.6	1.8	1.8	1.9
6th							
RENT	5	5.8	5.5	3.0	2.5	3.5	2.1
non-RENT	3	5.9	5.8	1.5	2.6	2.7	2.5
4th, 5th, 6th							
RENT	16	5.9	4.9	2.5	2.1	2.3	2.8
non-RENT	15	5.0	4.8	1.6	2.2	2.0	2.7
8th							
RENT	5	6.1	6.1	2.8	3.6	2.7	2.8
non-RENT	6	-	-	-	-	-	-

THE COST DATA

The data indicate the District of Columbia Schools provided approximately \$34,265 per class to each RENT class and \$34,424 to each non-RENT class in the study. However, the average class size in the RENT schools was 27.7, compared to 29.0 in the non-RENT schools. On a per student basis, DCPS funding amounted to \$1,237 per RENT student and \$1,187 to each non-RENT student. This difference in funding level was not statistically significant and there is no basis to infer that the effects of RENT were mitigated because a portion of the RENT resources supplanted DCPS resources.

Given that no supplanting effect has been shown, we can assume that the additional cost of RENT is more or less the cost of the resources directly provided by RENT, as shown in Table 5.

Total resource levels of \$328 and \$301 per student are targeted to reading and math students respectively, bringing the total resource, RENT and DCPS, to \$1,565 per reading student and \$1,538 per mathematics student. Non-RENT students receive approximately \$1,187 in resources annually. These differences are statistically significant.

IS RENT COST-EFFECTIVE?

We pose that question in order to remind the reader that only the policymaker can really answer the question, because only the policymaker is in a position to judge which measures of effectiveness are most appropriate for his needs. In this section we relate the cost and effectiveness data presented earlier.

We will not be using the adjusted gain score analyses, because they were done only on reading and mathematics subskills and not on general reading and mathematics scales. Because it is not possible for a policymaker to "buy" reading comprehension without reading vocabulary, and vice versa, we prefer to use the total measures which capture both effects in the reading dimension. Similar comments apply to mathematics. In discarding those analyses, we wish to point out that they did indicate the existence of significant RENT main-effects in reading comprehension and mathematics concepts and interactions effects in mathematics computation and reading vocabulary.

Tables 1 and 2 include columns labelled "\$/pc" and "\$/pt." These columns represent the average cost per student divided by average percentile gain and the average cost per student divided by the average change in raw score, respectively. In general, low ratios indicate that gains are being "purchased" more efficiently than gains associated with higher ratios.

Table 5

SUPPLEMENTAL RNP COSTS/STUDENT

	<u>Training</u>	<u>Instruction</u>	<u>Parent/Community Involvement</u>	<u>Total</u>
Reading	123	143	62	328
Math	113	131	57	301

Reading

At the fourth grade level, whether we consider Fall-Spring or Fall-Fall comparisons, the results are the same: (1) the differences in \$/pt cost-effectiveness ratios are not statistically significant; but (2) RENP is preferred to non-RENP in \$/percentile comparisons as the non-RENP percentile changes are negative.

At the fifth grade level, all cost-effectiveness ratios favored RENP. As noted previously, however, we are unable to attach statistical significance to this fact.

At the sixth grade level, the comparisons do not form a clear pattern: The Fall-Fall comparisons show RENP as less cost-effective in terms of \$/pt comparisons, but more cost-effective in terms of \$/percentile comparisons. The Fall-Spring comparisons show RENP to be more cost-effective in terms of both measures.

Mathematics

At the fourth grade level, considering the Fall-Fall data, RENP is seen as less cost effective in terms of \$/point comparisons, but more effective in terms of \$/percentile comparisons. The Fall-Spring data favors the non-RENP classes on both measures.

At the sixth grade level, the RENP program was more effective in the Fall-Spring comparisons, but the non-RENP program was more cost-effective in the Fall-Fall comparisons.

CONCLUSIONS

The analysis presented in this paper is a first step to a definitive cost-effectiveness analysis. It is not, in itself, definitive, because of the substantial theoretical problems with the data employed. We do not attach or imply any rigorous statistical credibility to the conclusions which follow. Rather, we consider them to be the most sound point estimates possible from the available data. Any significant statistical differences reported in this paper are consistent with the following conclusions.

RENP produced larger percentile gains at the fourth, fifth, and sixth grade levels in reading than did the DCPS program. Further, the additional investment required was more than offset by the additional gain produced.

In mathematics, at the fourth grade levels, RENT classes were more cost-effective in terms of percentile on a Fall-Fall basis, but less cost effective on a Fall-Spring basis. At the sixth grade level, the situation was reversed. At the fifth grade level, the non-RENT program was superior.